APRIL 1919

BULLETIN 239

# THE TOBACCO FLEA BEETLE

Z. P. METCALF AND G. W. UNDERHILL

NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION
CONDUCTED JOINTLY BY THE
STATE DEPARTMENT OF AGRICULTURE
AND THE
NORTH CAROLINA STATE COLLEGE OF
AGRICULTURE AND ENGINEERING

RALEIGH AND WEST RALEIGH

# THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

CONDUCTED JOINTLY BY THE

## STATE DEPARTMENT OF AGRICULTURE

AND THE

## NORTH CAROLINA STATE COLLEGE OF AGRICULTURE AND ENGINEERING

---

## BOARD OF AGRICULTURE

*W. A. GRAHAM, *Chairman*, Raleigh

| | | | |
|---|---|---|---|
| F. P. LATHAM | Belhaven | *A. T. MCCALLUM | Red Springs |
| C. W. MITCHELL | Aulander | *C. C. WRIGHT | Hunting Creek |
| *R. L. WOODARD | Pamlico | W. C. GRIER | Grassy Creek |
| *CLARENCE POE | Raleigh | H. Q. ALEXANDER | Matthews |
| R. W. SCOTT | Haw River | A. CANNON | Horse Shoe |

## BOARD OF TRUSTEES OF THE COLLEGE

GOVERNOR T. W. BICKETT, *Chairman*

| | | | |
|---|---|---|---|
| M. B. STICKLEY | Concord | *T. T. THORNE | Rocky Mount |
| T. T. BALLINGER | Tryon | *C. W. GOLD | Greensboro |
| W. H. WILLIAMSON | Raleigh | T. E. VANN | Como |
| O. L. CLARK | Clarkton | P. S. BOYD | Mooresville |
| EVERETT THOMPSON | Elizabeth City | W. E. DANIEL | Weldon |
| R. H. RICKS | Rocky Mount | *W. H. RAGAN | High Point |
| W. R. BONSAL | Hamlet | W. B. COOPER | Wilmington |
| D. R. NOLAND | Crabtree | A. M. DIXON | Gastonia |

W. C. RIDDICK (President College), West Raleigh

## STAFF OF THE AGRICULTURAL EXPERIMENT STATION

### ADMINISTRATION

| | |
|---|---|
| B. W. KILGORE | Director |
| C. B. WILLIAMS | Vice Director, Experiment Station |
| S. G. RUBINOW | Assistant to Director, Extension Service |
| F. H. JETER | Agricultural Editor |
| A. F. BOWEN | Bursar |
| H. C. EVANS | Auditor and Executive Assistant |
| MISS MARY S. BIRDSONG | Secretary to Director |

### AGRONOMY

| | |
|---|---|
| C. B. WILLIAMS | Chief in Agronomy |
| J. K. PLUMMER | Soil Chemist |
| W. F. PATE | Agronomist, Soils |
| E. C. BLAIR | Assistant Agronomist, Soils |
| S. K. JACKSON | Assistant Agronomist, Soils |
| R. Y. WINTERS | Plant Breeding |
| V. R. HERMAN | Assistant in Plant Breeding |
| N. E. WINTERS | Extension Agronomist |
| M. W. HENSEL | Specialist in Sugar Plant Production |
| S. O. PERKINS | Assistant in Soil Survey |
| L. L. BRINKLEY | Assistant in Soil Survey |
| S. F. DAVIDSON | Assistant in Soil Survey |
| W. A. DAVIS | Assistant in Soil Survey |
| E. H. MATTHEWSON | Tobacco Expert |
| A. R. RUSSELL | Assistant in Field Experiments |

### CHEMISTRY

| | | | |
|---|---|---|---|
| W. A. WITHERS | Chemist | R. A. FETZER | Assistant Chemist |
| ——— | Assistant Chemist | G. L. ARTHUR | Assistant Chemist |
| J. M. PICKEL | Feed Chemist | W. A. HARRIS | Assistant Chemist |
| W. G. HAYWOOD | Fertilizer Chemist | J. R. MULLEN | Assistant Chemist |
| E. S. DEWAR | Assistant Chemist | | |

### ENTOMOLOGY

| | |
|---|---|
| FRANKLIN SHERMAN, JR. | Chief in Entomology |
| Z. P. METCALF | Entomologist |
| R. W. LEIBY | Assistant Entomologist |
| J. E. ECKERT | Assistant Entomologist |
| C. L. SAMS | Beekeeping Specialist |
| W. A. THOMAS | Extension Entomologist |

## HORTICULTURE

| | |
|---|---|
| _____ | Chief in Horticulture |
| C. D. Matthews | Acting Chief, Division of Horticulture |
| J. P. Pillsbury | Horticulturist |
| L. R. Detjen | Assistant Horticulturist |

## ANIMAL INDUSTRY

| | |
|---|---|
| Dan T. Gray | Chief in Animal Industry |
| R. S. Curtis | Associate in Animal Industry |
| Stanley Combs | Dairy Experimenter |
| B. F. Kaupp | Poultry Investigator and Pathologist |
| A. J. Reed | Dairy Farming |
| W. W. Shay | Assistant in Swine Extension |
| A. G. Oliver | Poultry Club Agent |
| E. C. Warden | Assistant Poultry Club Agent |
| F. R. Farnham | Assistant in Dairy Farming (Cheese Work) |
| A. C. Kimrey | Assistant in Dairy Farming |
| D. R. Noland | Assistant in Dairy Farming (Cheese Work) |
| F. T. Peden | Assistant in Beef Cattle |
| J. W. Sloss | Assistant in Beef Cattle |
| J. B. Peery | Assistant in Beef Cattle |
| Albert Miller | Assistant in Beef Cattle |
| Earl Hostetler | Assistant in Beef Cattle and Swine |
| W. H. Ferguson | Assistant in Sheep |
| George Evans | Assistant in Sheep |

## PLANT PATHOLOGY

| | |
|---|---|
| F. A. Wolf | Plant Pathologist |
| W. H. Tisdale | Associate, Botany and Plant Pathology |
| R. A. Jehle | Extension Pathologist |

## DRAINAGE

| | |
|---|---|
| H. M. Lynde | Senior Drainage Engineer |
| F. O. Bartell | Junior Drainage Engineer |

## VETERINARY

| | |
|---|---|
| G. A. Roberts | Veterinarian |

## MARKETS AND RURAL ORGANIZATION

| | |
|---|---|
| W. R. Camp | Chief, Division of Markets |
| O. J. McConnell | Cotton Grading and Marketing |
| Chas. S. Jones | Specialist in Livestock Marketing |
| W. W. Garnett | Assistant Superintendent of Credit Unions |
| G. Shumaker | Assistant in Marketing Fruits and Vegetables |
| Bolling Hall | Assistant in Marketing Fruits and Vegetables |

## FARM MANAGEMENT

| | |
|---|---|
| J. M. Johnson | Agriculturist |

## FARM FORESTRY

| | |
|---|---|
| Harry B. Krausz | Farm Forestry Specialist |

## FARM MACHINERY

| | |
|---|---|
| E. R. Raney | Farm Machinery Specialist |

## BRANCH STATIONS

| | |
|---|---|
| R. W. Collett | Assistant Director, in charge Branch Stations |
| F. T. Meacham | Assistant Director Iredell Branch Station, Statesville |
| W. J. Brockington | Assistant Director Pender Branch Station, Willard |
| C. E. Clark | Assistant Director Edgecombe Branch Station, Rocky Mount |
| E. G. Moss | Assistant Director Granville Branch Station, Oxford |
| S. C. Clapp | Assistant Director Buncombe Branch Station, Swannanoa |
| H. Bocker | Assistant Director Black Land Branch Station, Wenona |

## FARM DEMONSTRATION WORK

| | |
|---|---|
| C. R. Hudson | State Agent |
| H. H. B. Mask | Assistant State Agent |
| E. S. Milsapps | District Agent, Western District |
| T. D. McLean | District Agent, Central District |
| J. M. Gray | District Agent, Mountain District |
| O. F. McCrary | District Agent, Northeastern District |
| N. B. Stevens | District Agent, Southeastern District |

## HOME DEMONSTRATION WORK

| | |
|---|---|
| Mrs. Jane S. McKimmon | State Agent |
| Mrs. J. H. Henley | District Agent, Western District |
| Mrs. Lizzie R. Edgerton | District Agent, West Central District |
| Miss Laura M. Wingfield | District Agent, Central District |
| Mrs. Estelle T. Smith | District Agent, East Central District |
| Mrs. Cornelia C. Morris | District Agent, Eastern District |

# SUMMARY

The Tobacco Flea Beetle or "Flea Bug" is one of the worst pests of tobacco under North Carolina conditions. The injury caused by this insect consists of eating small holes through the leaves. This insect lives over the winter under leaves and trash, around the edges of tobacco fields or in adjoining woods. They come out of hibernation early in the spring and attack the young tobacco plants in the seed beds, and seriously injure them. Frequently it is impossible to get a stand of plants, because of the attacks of this insect. Later when the tobacco plants are transplanted to the fields they attack the plants and cause a weakened condition so that the plants die and have to be replanted. Still later in the season they attack the nearly matured leaves in the field, and while the damage they do at this season of the year is very extensive, it has not been noticed so much of late, because low grade tobacco has been selling at a relatively high price. Besides tobacco the tobacco flea bug lives on various weeds and cultivated plants belonging to the Nightshade Family, such as the potato, tomato, common nightshade, horse nettle and ground cherry.

The life history may be summarized as follows: The adults hibernate over winter, emerging as soon as any food plant is available in the spring. Usually they damage the tobacco beds very extensively at this time. The adult tobacco flea beetle is a small, active insect that feeds by eating holes through the leaves. The amount of green food that they eat is almost beyond belief, averaging ten times their own weight per day. This is equivalent to the average man eating about a ton of food per day, and the average cow eating five tons of food daily. The tobacco flea beetle hibernates only in adult stage under leaves, grass, etc., along the edge of the tobacco fields or other suitable places. They go into hibernation soon after the first killing frost, and continue there until food is available in the spring. Eggs are laid in the ground from April to September. They are laid near the surface of the ground usually under the tobacco plant, where they hatch in approximately a week. The eggs are very small. It would take sixty laid end to end or one hundred and twenty-five laid side by side to equal an inch. Larvae occur on the roots of tobacco from May to October. They are very small yellowish grubs about one-sixth of an inch long, when full grown. They live on the fine hairlike roots of the tobacco plant. It takes nearly two weeks for them to become full grown. The pupae are found in small cells just beneath the surface of the

ground under the tobacco plants. The control measures recommended in this bulletin are directed towards three main points. The control on the plant beds chiefly by dusting or spraying, dipping the plants at transplanting time, and the destruction of the suckers in the field. Other control measures are also discussed.

# THE TOBACCO FLEA BEETLE

VIII - 231

By Z. P. Metcalf and G. W. Underhill

The tobacco flea beetle has long been recognized as one of the most important insect enemies of tobacco in North Carolina. The senior author in a bulletin, published in 1909, accorded this insect first rank as a pest of tobacco. Since that time the amount of damage which it does has apparently increased, although the loss in a monetary way has perhaps decreased slightly, due to the fact that the poorer grades of tobacco sell for a relatively higher price today than ever before. While the damage in the field is thus compensated for, the damage in the beds is a serious problem which is ordinarily not appreciated by tobacco growers. The present bulletin has been prepared, therefore, to present to the farmer a discussion of this pest, and aims to point out to him the nature of the damage done by this flea-beetle, together with suggestions of proper control measures as well as a discussion of the life history of this insect on which the control measures are based, for without a clear understanding of the life history of the insect it is impossible to apply the proper remedies.

## COMMON NAMES

This insect is known generally as the "flea-bug" by farmers in this and other states. Sometimes, although rarely, tobacco farmers speak of it as the "tobacco flea-bug." Strictly speaking, however, the insect should be called the tobacco flea-beetle, because it is a beetle and not a bug. The term "bug" should be reserved for insects such as the stink bugs, the terrapin bug, squash bug, etc. This distinction would hardly be worth insisting upon were it not for the fact that the true bugs are provided with piercing mouth parts by means of which they pierce the leaves and stems of plants and suck out their juices, whereas the beetles have chewing mouth parts and actually eat away the leaf or other parts of the plant. Regardless of this fact, tobacco farmers generally speak of the tobacco flea-beetle as "sucking the plant." With these reasons in mind the name "Tobacco flea-beetle" is used throughout this report, as this is the only name that is distinctive.

## DISTRIBUTION

The accompanying maps will show the distribution of this insect as far as the records show. Apparently it is rather widely distributed in the tropical and temperate regions of the world. Outside of the United States we have records of its occurrence in Canada, Mexico, Panama, Cuba, Bahamas, Porto Rico, Ceylon, and the Philippine Islands. In the United States the insect perhaps occurs wherever tobacco is grown. The

FIG. 1—Map of the world, showing recorded distribution of the Tobacco Flea Beetle. (Original.)

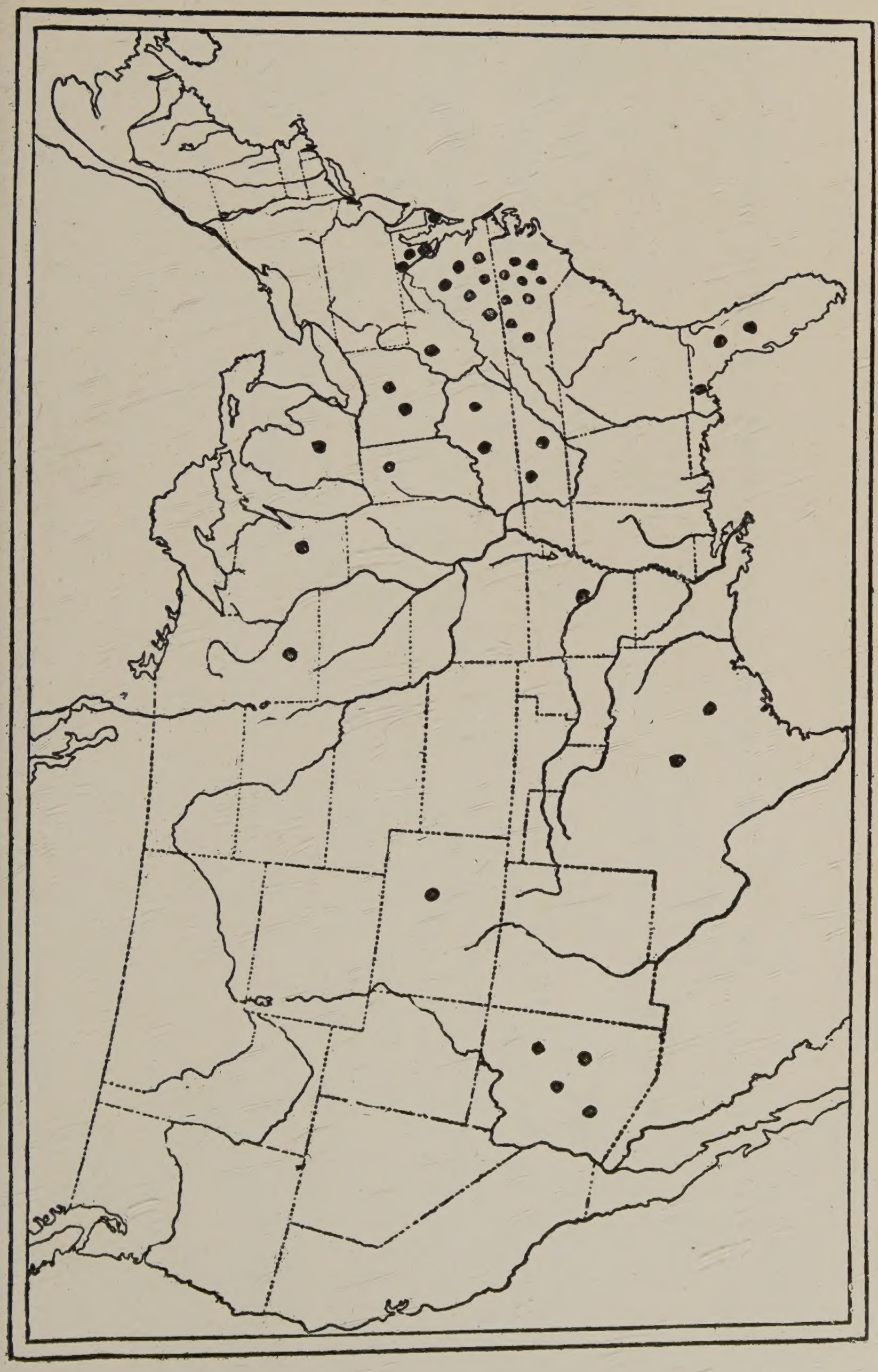

FIG. 2—Map of the United States, showing distribution of the Tobacco Flea Beetle. (Original.)

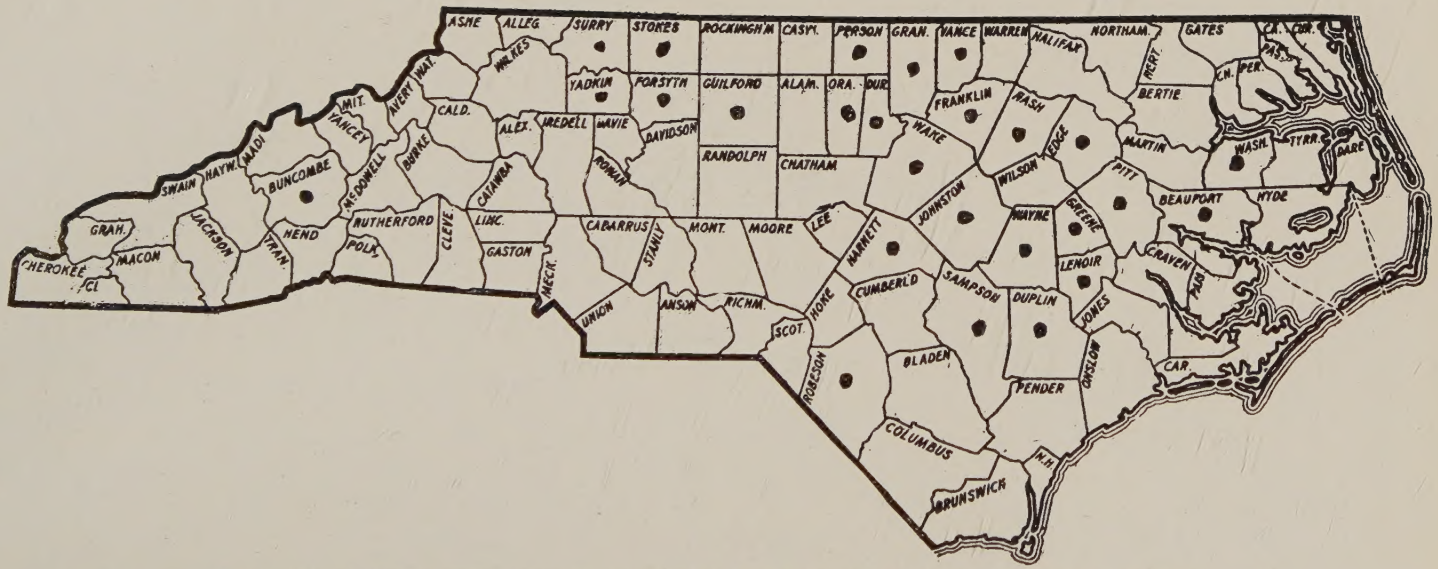


FIG. 3—Map of North Carolina, showing the recorded distribution of the Tobacco Flea Beetle. (Original.)

maps will show the actual records. In North Carolina it has been found wherever there has been an opportunity to examine the growing tobacco. It is presumed, therefore, that it occurs throughout the State.

## HISTORY

The tobacco flea-beetle was originally described by Fabricius in 1801, and has long been recognized as an important insect pest of tobacco in America. It has been discussed by all of the writers who have treated of the general subject of tobacco insects, especially Howard 1898, Metcalf 1909, and Morgan 1910.

## IMPORTANCE OF THIS INSECT

The tobacco flea beetle is without doubt the most important insect pest of tobacco in North Carolina. It is given this rank for the following reasons: First, because it damages the tobacco in the plant beds as well as in the field. There is no other insect enemy of tobacco of prime importance that damages both the young plant in the bed and the growing crop. The tobacco flea-beetles commence their attacks almost as soon as the plants come up, and continue them as long as the plants are growing in the field, and, not infrequently, they follow the harvested crop to the barns where they continue their attacks until excessive heat kills them or drives them out. In the second place, the small size of the insect, together with the large number of individuals which occur, makes the tobacco flea-beetle a very difficult pest to control. In the third place, the effect of the flea-bugs' work is to lower the grade of the tobacco. This is effected by actual reduction in the weight and "body" or quality of the leaves which have been damaged by the flea-beetle. The result is that the tobacco farmer not only produces fewer pounds of tobacco, but the damaged tobacco is placed in a lower grade which sells, even at the present high prices, for much less per pound than tobacco which has not been damaged.

## INJURY OFTEN MISTAKEN FOR THAT OF THE FLEA-BEETLE

The adults of the corn bud worm, or root worm *(Diabrotica 12-punctata)* are sometimes found feeding on the plant beds, and frequently they are found feeding on the plant leaves in the field. These punctures might be mistaken for those of the tobacco flea-beetle, but they are much larger. There are two black flea-beetles in practically every field in very small numbers; a medium large black one *(Chaetocnema protensa)*, and a small one which is the potato flea-beetle *(Epitrix cucumeris)*. Only a few of these are to be found, and they seem to disappear in the latter part of the season. Grasshoppers often do much damage, especially the little grouse locusts *(Tettigidae lateralis)*, which make

small holes resembling the flea-beetles' injury. Also in the plant beds plant hoppers *(Membracidae)* and leaf hoppers *(Jassidae)* are often very plentiful. Their feeding punctures might be attributed to the beetles also, but none of these do much damage, and are hardly worthy of any consideration in connection with the flea-beetles.

## FOOD PLANTS

The tobacco flea-beetle feeds by preference upon any and all of the members of the *Solanaceae,* or Nightshade, family. The plants of this

FIG. 4—The Horse Nettle. A weed which is a favorite food plant of the Tobacco Flea Beetle. (Original.)

family are its natural hosts. The authors have found them feeding on the following named members: the potato *(Solanum tuberosum),* the wonder berry *(Solanum nigrum* variety), horse nettle *(Solanum carolinense),* the black or common nightshade *(Solanum nigrum),* the egg plant *(Solanum melogena), the tomato (Lycopersicum esculentum),* the ground cherry or husk tomato *(Physalis pubescens),* the jimson or Jamestown weed *(Datura stramonium),* the sheep bur *(Solanum rostratum),* and the tobacco *(Nicotiana tabacum).* Of these, the beetle seems to prefer the tobacco among the cultivated plants, and the husk tomato among the wild plants.

In the field in spring and late fall, when there are no tobacco plants on which the insects could feed, the authors have found the beetles feeding on the following plants, other than of the Solanaceous family: cabbage and turnip of the Cruciferae family; eaten a little around the edges of the plant beds; the frost flower weed (Aster sp.), the butter weed *(Erigeron canadensis),* the butterfly weed *(Asclipeas tuberosa),* are all among the plants on which a very few beetles were taken in the early spring. In the fall pokeweed *(Phytolacca decanda),* and the cowpea *(Vigna sinensis)* were relished very much when no better host plant was near. A few beetles have been taken on a thistle. None of the above plants were much relished, and were simply used temporarily to tide over a short period until more desirable plants were available.

FIG. 5—The Husk tomato. A favorite wild food plant of the Tobacco Flea Beetle. (Original.)

In the laboratory the susceptibility of several plants was tried out. Young tender leaves were placed in cages with the beetles. They ate the sheep sorrel, morning glory, and violet leaves a very little, and, apparently, would not feed on beans, corn, plantain, clovers, honeysuckle, and dewberry.

FIG. 6—The Jimson or Jamestown weed. A common weed which furnishes an abundance of food for the Tobacco Flea Beetle. (Original.)

## NATURE OF DAMAGE

The damage to the tobacco plant consists of eating small holes either partially or entirely through the leaves. In the tobacco beds the tobacco flea-beetles not infrequently, if left undisturbed, check the plants so severely that it is often quite impossible for the farmer to secure enough strong plants for transplanting. Even if enough plants are secured, it frequently throws the season for transplanting so late that the plants do not mature well in the field. Hence the crop is cut short.

Another factor that should be taken into consideration, in this connection, is the fact that the late tobacco is damaged much more by the flea-beetles than all other kinds of tobacco insects. Not infrequently, the beds will be so badly damaged that they will be abandoned by the farmer, thus resulting in a complete loss of labor, fertilizer and seed. Although tobacco growers generally are familiar with the work of the tobacco flea-beetle in the field, very few appreciate that it is the same insect which damages the bed. The damage on the beds is usually

attributed to the various kinds of flies which are found abundantly in tobacco beds. These flies are much larger than the tobacco flea-beetle and are readily observed because they usually light on the cloth or on the upper sides of the leaves when the cover is removed, while the flea-beetles have the habit of dropping to the ground when they are disturbed. These flies are of various kinds, and, so far as observed, they all belong to species which breed in stable manure which is commonly used as a plant bed fertilizer. None of these flies feed on growing plants, hence they can do no damage to the plants in the beds.

## LIFE HISTORY SUMMARY

The following summary is based on the data given in the following pages. The adults hibernate over the winter (Fig. 7), going into hibernation soon after the first killing frost. The latest recorded date is

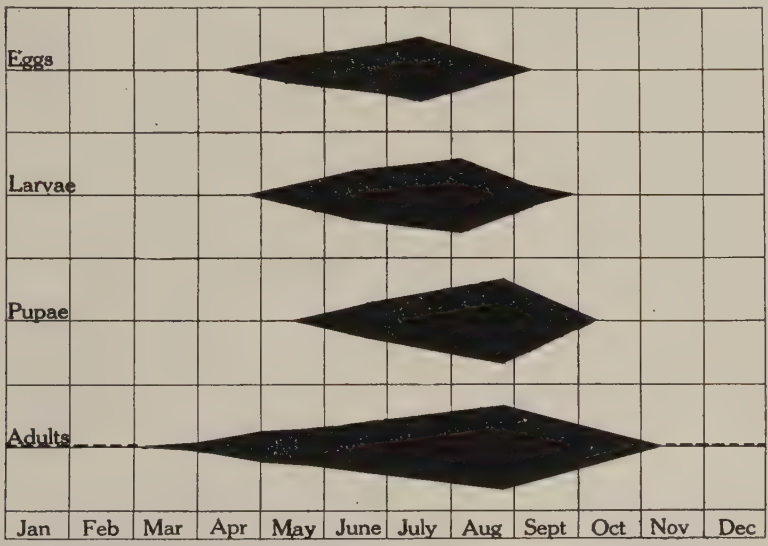


FIG. 7—Summary of the life history of the Tobacco Flea Beetle, showing months in which the various stages occur, also their prevalence. The different broods are not taken into consideration. (Original.)

November 7. They begin to emerge early in the spring, coming out just as early as the plants appear on the beds, and continue to collect on the beds until transplanting time. The first brood of adults appears about the last of May, and the numbers of adults increase until harvest time. From harvest time the numbers decrease rapidly until they are driven into hibernation.

The adults begin to lay eggs very soon after they emerge in the spring. The earliest recorded date is April 17. Large numbers are laid by the last of May, and the maximum is reached during June and July. After the middle of August very few eggs are found.

The first larvae hatch about the first of May. The greatest numbers occur in June and July. In late August they are much less numerous. The latest one taken was October 3.

The first pupae appear about May 15 or 20. The number increases rapidly throughout June. They are most abundant from June to late August. The latest date on which they have been taken is October 3.

The evidence shows that there are at least four broods of the tobacco flea-beetle in the eastern part of the State, but the broods overlap so much that they are difficult to follow.

## THE EGG

### DESCRIPTION

The egg (Fig. 8) is elongate-ellipsoid and is generally a little pointed at one end, and broadly rounded at the other. Its shape may be changed

FIG. 8—Egg of Tobacco Flea Beetle greatly enlarged. (Original.)

to accommodate itself to other eggs and to the surrounding surfaces. Just after the egg is laid the color is pearly white, but as it grows older it becomes more and more yellowish until a medium-light lemon yellow color is assumed, which is due to the developing embryo. Under the microscope the surface shows a distinct sculpturing. These very small somewhat irregular depressions cover the chorion, and give it a sort of network appearance. The size of the eggs varies considerably.

FIG. 9—Leaf of Tobacco plant, showing injury. (After Metcalf, N. C. Dept. Agr.)

The length is usually about two and one-half times the width. The average size of 25 eggs taken at random throughout the season was as follows: average length .4095 mm. (about 1-60 of an inch), and average width .1806 mm. (about 1-125 of an inch).

The eggs of the tobacco flea-beetle are laid on, or very near, the sur-

face of the ground immediately under the host plant. Occasionally a few eggs may be deposited on the body of the stalk at the surface of the soil, but this condition is very rare. No eggs were ever found in the field on the leaves of the plants.

The period of incubation of the eggs hatched under laboratory conditions ranged from 6 to 8 days in midsummer. The majority of the eggs hatched in 6 to 7 days. Moisture and temperature greatly influence the length of the incubation period, thus early and late in the season the incubation period would extend to nine days or more. The average, under field conditions, is assumed to be about 7 days.

The data on the number laid by each female under laboratory conditions shows a daily average of 2.21 eggs. While no definite data was obtained on the length of the active life of a female beetle, it is assumed that they live for at least 90 days, thus an average female would lay about 200 eggs during the season under normal field conditions.

## THE LARVA

### GENERAL DESCRIPTION

The larvae of the tobacco flea-beetle are filiform, and contain twelve segments. Each segment is about the same diameter except the last one, which is smaller. The thoracic segments each bear a pair of short segmented legs. The remaining segments are legless. The ultimate segment (Fig. 13) has a pair of pro-legs, by means of which the larva is able to cling to surfaces which are comparatively smooth. There are nine pair of spiracles: one pair on the pro-thorax and eight pair on the abdominal segments 1-8, located just above a slightly prominent lateral longitudinal fold on the segments. The spiracles are rather inconspicu-

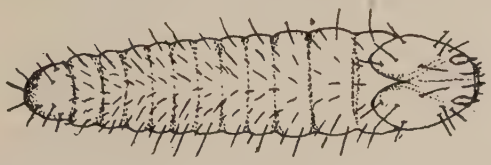

FIG. 10—Newly hatched larva of the Tobacco Flea Beetle, greatly enlarged X 100. (Original.)

ous, because there are no distinctly colored lips or borders to them. The color of the larvae is dirty white, except the head, which is "honey yellow" with dark reddish brown mouth parts. The mandibles are tridentate and of a very dark brown color. The hairs are somewhat irregularly in two rows around each segment.

Immediately after hatching (Fig. 10) a larva is less than one mm. long (.50 to .75 mm. long; .12 to .15 mm. wide); nearly cylindrical, somewhat flattened dorso-ventrally; milky white in color, except the head, which is yellowish brown in color. The head at this age is very long and considerably flattened dorso-ventrally. In proportion to the

rest of the body it is much longer, broader, and flatter than at any other stage. The head nearly equals the length of the three thoracic segments. This difference in proportion of head to the body lasts only for a short period of time. Also the body which is somewhat flattened and broader, in the middle region, becomes more and more cylindrical after the first day, until the normal proportions are assumed about the third day.

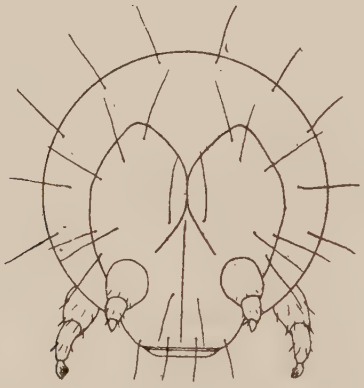

FIG. 11—Head of larva of Tobacco Flea Beetle, showing arrangements of hairs. (Original.)

The hairs on the body appear more thickly crowded and longer at this stage than any other.

The length of the average larva when about one week old is about 3.5 mm., and the thickness about .35 mm.

The cephalic lobes are very distinctly separated by a rather prominent medial suture which reaches from the dorsal margin of the epicranium, down the middle of the frons, to the margin of the inconspicuous clypeus. Each lobe of the epicranium is pointed posteriorly (Fig. 11). Two diverging sulci extend from the middle of the epicranium outward and downward nearly to the base of the rudimentary antennae. These sulci

FIG. 12—Larva of Tobacco Flea Beetle, showing general characters enlarged X 15. (After Metcalf, N. C. Dept. Agr.)

gradually become evanescent near the antennae. There are seven hairs on each lobe of the epicranium and the gena above and posterior to the diverging sulca. (Frontal view.) There are four hairs on each half of the frons. (See Fig. 11 for the arrangement of the hairs.) The clypeus is very short dorso-ventrally and nearly straight on the dorsal margin

and slightly concave on the ventral margin. The labrum is broadly semicircular, the ventral border being truncate and slightly lobed. There are four hairs in a row running transversely across the face of the labrum. The mandibles are strong, dark brown in color, and each has a tri-dentate cutting edge. They are set far apart and are short and robust so that the

Fig. 13—Larva of Tobacco Flea Beetle, showing arrangements of hairs. Enlarged X 20. (Original.)

cutting edges do not overlap as they do in the adult. The maxillary palpi are apparently four jointed; the labial palpi three jointed. The mature larva has an average length of 4.23 mm.

As the result of a study of the habits of the larvae, under field conditions, it was found that they feed upon the roots of the plants of the Solanaceous family. No larvae were ever found outdoors feeding upon the leaves. In special cases it has been found they not only feed upon, but often tunnel the stalks of tobacco and ground cherry plants for a distance of several inches. This is especially noticeable if the plants are accidentally partly buried.

In the field the larvae were normally found only in the ground among the fine rootlets (Fig. 14). They were limited to this root zone, and fed largely upon the fine rootlets. Occasionally a large root was girdled or tunneled, and thus greatly weakened or completely ruined. It is reasonable to conclude that considerable damage is done by the larvae of the tobacco flea-beetles where they are in large numbers. Granting that they are very small and their feeding capacity very limited, it must be admitted that the sum total injury to the tobacco crop in the State, during the growing season, is no small item.

The feeding zone of the larvae is limited. Nearly all were found within a radius of ten or twelve inches of the plants, and feeding on the small rootlets (Fig. 14) near the surface at an average depth of less than one inch. It was found that the cultivation, the moisture content of the soil, and the amount of shade given by the bottom leaves, each influenced the limits of the feeding zone, both as to the distance from the stalk and the depth in the ground. The extremely hot sunshine in August drove the larvae much deeper in the soil, especially after the bottom leaves had been primed off. This suggests the advisability of having the rows wider apart, and of priming off the bottom leaves when the crop is laid by, so as to admit as much sunshine as possible. This practice would greatly lower the percentage of eggs that hatch, and also make it unfavorable for the development of the larvae that did hatch, thus greatly increasing the mortality. Priming off the bottom leaves is already a common

FIG. 14—Tobacco stalks showing the small rootlets on which the Tobacco Flea Beetlelarvæ feed. (Original.)

practice with some farmers, but it is not used with any idea of checking or controlling the flea-beetle. This is a method of field control that can be safely followed.

The exact length of the larval stage from hatching to pupation has not been determined. Every method that could be devised has been tried without any success. Larvae have been kept under laboratory conditions for twelve days, where they reached an average length of 4 mm., but they all died before pupating. Numbers of larvae of the same average size were collected in the field and placed in breeding cages where they pupated in from four to five days. These figures added to the life of the larva, as indicated above, would give the length of the larval stage as from fourteen to sixteen days. These figures are approximately the same as those determined by Chittenden 1899.

## THE PUPA

### GENERAL DESCRIPTION

When the larva is about ready to transform to the pupa a simple, crude pupal cell is made about one-half to one inch deep in the soil. The cell is formed by contortions of the body. In this cell the larva becomes

FIG. 15—Pupa of Tobacco Flea Beetle. Ventral view much enlarged. (Original.)

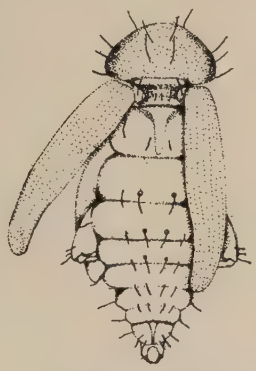

FIG. 16—Pupa of Tobacco Flea Beetle. Nearly mature. Much enlarged. (Original.)

inactive and changes to the pre-pupa. The length of the prepupal stage is estimated to be about 30 to 36 hours.

The general appearance of the tobacco flea-beetle pupa is very typical of the Chrysomelids (Figs. 15 and 16). The head is directed sharply caudad with the frons nearly in straight line with the ventral surface of the abdomen. The mouth-parts lie partly over and between the first tarsal joints of the pro-thoracic legs. The antennae extend caudad, and are bent underneath the pro- and mesothoracic legs. The antennal segments 5 to 8 are completely invisible under the legs, while segments 9 to 11 point toward the mesal line, and lie posterior to and almost parallel with the tibia of the mesothoracic legs. The elytra are folded tightly on the ventro-lateral surfaces of the abdomen. The wings lie underneath

the elytra and more ventral. The legs are each folded with the femur pointing away from the mid-line and the tibia toward it. The tarsi are directed caudad along the mesal line. The pro- and mesothoracic legs are folded close together directly ventral to their respective thoracic segments. The metathoracic legs are folded considerably caudad to these and the wings lie ventrad across the femur and tibia of each. The abdomen is composed of seven distinct segments, with a very characteristic pair of anal hook-like appendages. Each abdominal segment has four distinct setae on the dorsal surface, and one prominent seta on each lateral edge. Also the thoracic segments have rather distinct setae on the dorsal surface. The pro-thorax has twelve setae. See Figs. 15 and 16 for all of the above characteristics and arrangement of the setae.

The very young pupae are larger and more slender than the older ones. The average length of the pupa is 1.75 mm., and the width across the meta-thoracic femur is .85 mm.

The first pupa was found in the field on July 16. They had been overlooked up to that time. The last one found was on October 3, in an old plant bed. Throughout August they were easy to find, but in September they began to get very scarce.

In order to get the exact time of pupation, larvae were collected and kept until they changed to the pupal stage. The best results in rearing pupae were obtained by the use of one-half inch glass tubes about two inches long open at both ends. These were filled loosely with dark loamy soil, and one end buried in sand in tin boxes. The sand in the tin boxes was watered and the soil in the tubes kept moist by the capillary rise of water, thus it was easy to control the moisture content. The nearly mature larvae were placed in these tubes with a piece of cheese cloth tied over the top. Usually the pupal cells were made about one-half inch deep in the soil. It was easy to get exact records from these tubes.

The following table shows the average length of the pupal stage as determined during the summer (1917).

TABLE I

SHOWING THE LENGTH OF THE PUPAL STAGE

| No. of Pupa | Date Pupated | Date Emerged | Length of Pupal Stage (No. Days) |
|---|---|---|---|
| 1 | 7/22 | 7/26 | 4 days |
| 1 | 7/26 | 7/31 | 5 days |
| 2 | 7/26 | 7/30 | 4 days |
| 2 | 8/9 | 8/13 | 4 days |
| 5 | 8/13 | 8/17 | 4.5 days |
| 1 | 8/14 | 8/18 | 4 days |
| 1 | 8/16 | 8/20 | 4.5 days |
| 1 | 8/17 | 8/22 | 5 days |
| 1 | 8/17 | 8/23 | 5.5 days |
| 1 | 8/18 | 8/23 | 5 days |
| 2 | 8/21 | 8/25 | 4 days |
| 2 | 8/23 | 8/27 | 4 days |

Average length of the pupal stage 4.46 days.

## ADULT

### GENERAL DESCRIPTION

The adult tobacco flea-beetle (Figs. 17 and 18) is very small, averaging from 1.5 to 2 mm. in length. Its dull reddish-yellow color, with the irregular dark fuscous patch across the middle of the elytra is distinctive.

Blatchley (1910) gives the following description: "Oblong-oval, subconvex. Dull reddish-yellow; elytra often with a fuscous transverse cloud at middle; abdomen brown, antennae and legs pale reddish-yellow, the four outer joints of former and hind femora of latter often darker. Thorax convex, shining, nearly twice as wide as long, not narrowed in front; antabasal impression evident but not deep; surface distinctly but

FIG. 17—Adult of Tobacco Flea Beetle. Much enlarged. (After Metcalf, N. C. Dept. Agr.)

rather finely and sparsely punctate. Elytra very little wider than thorax, umbone feeble, punctures rather coarse and not crowded on disk; finer and more close set on sides, where the intervals are subconvex. Length 1.5-2." (See Fig. 17)

In addition to the above the following details are added:

*Head.*—Vertex very finely and somewhat sparsely punctate without hairs, except a patch of four setae on each side just above the oblique ridges on one of the "V" on the face and mediad to each eye. The frons and frontal carina have several hairs arranged as shown in Fig. 19. A row of eight setae just dorsal to the clypeal suture, and a row of four

prominent bristles extends across the small blunty rounded labrum near its ventral border. Each gena has several bristles or hairs on the sides below the eyes. The antennae are eleven jointed. The first segment is about twice the size of the second, both of light reddish-yellow color; segments three to six, inclusive, are smaller, more slender, and of a light golden yellow color; segments seven to eleven, inclusive, are larger and gradually darker towards the tip; the eleventh segment nearly black, with the end pointed and nipple-like. All the segments are pubescent.

*Mouthparts.*—The mandibles are very strong and overlap for about half their length. Each has five prominent teeth, curved rather sharply inward. The maxillae are rather small, palpi four jointed, the lacinia

FIG. 18—Adult of Tobacco Flea Beetle, showing the arrangements of hairs. (Original.)

has a thick tuft of rather long coarse bristles across the broadly truncate free end, which makes these very efficient appendages for catching and holding the bits of leaf tissue cut off by the mandibles. The labium is very small with a rather inconspicuous three jointed palpi.

*Thorax.*—Reddish golden-yellow, strongly convex, dorsal surface shiny, rather shallowly, coarsely and sparsely punctate; front angle obliquely truncate with a small tooth and a prominent seta at the posterior limit of the angle; the lateral border narrowly margined and slightly serrate along the edge with several bristles at almost regular intervals; antebasal impression is shallow but evident.

*Elytra.*—Light yellow in color, transparent, except for a fuscous band across the middle. There is a distinct dark triangle behind and to the sides of the scutellum, and a dark area over the last abdominal segment. These areas are not covered by the wings, which are folded underneath the elytra, thus the dark reddish dorsal surface of the abdomen shows

through the transparent elytra. Ten striae of coarse punctations are on each elytra; each subconvex interval has a row of semierect hairs; the inflexed sides are serrate along the entire length; the teeth are semicircular in outline with spaces between about equal to the width of the teeth.

*Abdomen.*—Five segmented; first segment almost equal in length to all the rest, coarsely punctate and alutaceous on the ventral surface; second, third, and fourth segments narrow, all three about equal to the fifth in width, each finely and sparsely punctate; fifth segment narrowed

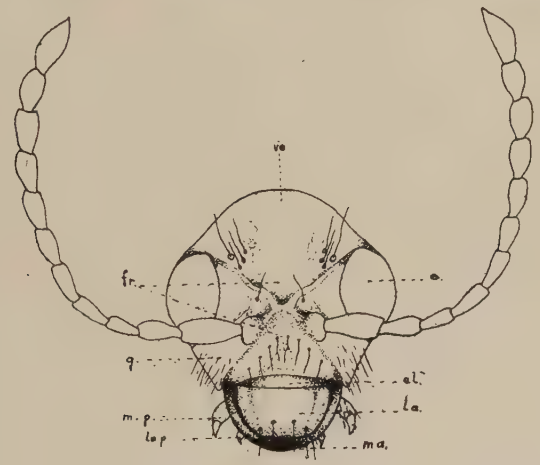


FIG. 19—Front of head of adult Tobacco Flea Beetle, showing arrangements of hairs. (Original.)

behind with the genital and anal plates at the tip; ventral surface pubescent.

*Legs.*—The legs are reddish-yellow except the femora of the metathoracic legs which are darker, reddish-brown. The hind femur is extremely well developed for leaping, and the tibia of this leg has a prominent sharp spur on the distal end. The tarsi are all apparently four jointed.

## HABITS OF ADULTS

The tobacco flea-beetle is a leaf-eating insect, and it is the adult that does most of the damage. All flea-beetle injury is characterized by small round, or irregular feeding punctures scattered over the leaf surface, or by a more or less complete skeletonization of the leaf. The last brood of the tobacco flea-beetle skeletonizes the leaf to some degree, but ordinarily the injury is in the form of small round holes. These feeding punctures may be cut partly or entirely through the leaf.

On the plant bed the beetles feed principally on the under side of the leaves. Most of the punctures observed on young tender plants are appa-

rently cut from the under side. (Fig. 20 shows this point very well.) Often a leaf that shows very little or no damage from above will show considerable signs of feeding on the under side. When infestation is general and the plants are small, the whole plant may be devoured.

After the plants are transplanted, and before they begin to grow, the beetles feed on the under side of the leaves, principally those that are somewhat rolled or folded, and those that lie on the ground. If many

FIG. 20—Under surface of young tobacco leaves, showing feeding punctures. (Original.)

beetles are present the entire leaf surface will soon be shot full of holes, and the leaf will commence to dry up. They usually continue to feed on these leaves as long as there is any green tissue, and plants are frequently killed by the attack of the beetle at this time.

Just as soon as growth begins and the tender leaves grow out, nearly all feeding is shifted to the new growth. The beetles were rarely ever seen feeding on the bud leaves.

As the plants grow and as the sun gets hotter in mid summer, the feeding is confined to the lower leaves almost entirely. Very few beetles do much feeding above the middle of the plant. It is believed this is due to the fact that the beetles are provided with better shade.

In the latter part of the season, after housing (or priming) has begun, particularly in young tobacco, the feeding becomes very general on all leaves, even the tips. On older tobacco the beetles seem to collect and

feed principally on the stipules of mature leaves close up to the main stalk, or on the tender suckers. Very often the main stalk will show very much sign of chewing, indicated by irregular dark areas.

The leaves that nearly touch the ground seem to be perferred by the beetles. They often collect on such in large numbers. The folded leaves are usually eaten so badly that they soon turn yellow and dry up prematurely.

The beetles feed nearly anywhere on the leaf surface, but apparently the majority of the holes are near the margin of the leaves. The beetles are less active in cool weather in early spring, and late in the fall, than they are during the heat of the summer, although the damage that they do may be more noticeable at this season of the year, because the plants are not growing rapidly. The beetles are more active during the middle of the day than early in the morning or late in the evening. This is especially noticeable early in the season when the nights are cool.

## THE AMOUNT EATEN DAILY BY EACH BEETLE

The amount of damage done by these beetles in the field is not realized by the average farmer. In fact, it is very difficult to estimate its extent, because there are several factors that come in. Some of these are: (1) the check upon the growth of the plant in the field, thus greatly lowering the average number of pounds per acre; (2) the increased spread of fungus diseases in the field by the beetles, and the giving of spores a good starting place in the feeding punctures made; (3) a possible bad effect upon curing the tobacco after it is put in the barn; and (4) the effect upon the price when put on the market. An estimation of some of these could not be made, but it was thought possible to approximately estimate the amount eaten.

In order to determine this amount, tobacco leaves that had previously been weighed were placed in cages containing a known number of adults. At the same time leaves which had been slashed with scissors were placed in cages without beetles to act as a check on evaporation. The two sets of leaves were removed from the cages every twenty-four hours and carefully weighed. The difference in the weight of the leaf before being placed in the cage with the beetle and at the end of twenty-four, minus the percentage of evaporation, divided by the number of beetles, has been taken as the amount eaten by each beetle. In all 743 beetles were used, and the average amount eaten by each beetle was 10.3 times its own weight. If each beetle eats this amount of green tobacco daily, and we assume that in an average infestation there are 15-20 beetles to the plant, each one feeding actively for a period of 100 days, then with 5,000 plants per acre, the total amount of green tobacco eaten by the beetles each season would be about *100 pounds per acre.* If it is assumed further that only 20 per cent of this weight is marketed in well cured

tobacco, which is worth .35 per pound, there is a direct loss of $7 per acre.

The above estimate is believed to be very conservative, and takes into consideration only one factor. Probably the greatest damage done by the beetles is in checking the growth of the plants, which have to suffer from the attack of these beetles from the time they come up on the plant-bed until mature in the field. The second factor in importance is the loss in quality of the marketable tobacco. A great loss also comes from an irregular stand of plants in the beginning of the season, and the necessity of resetting. The direct loss in pounds actually eaten by the beetle is certainly not as important as any of these.

## HIBERNATION

The tobacco flea-beetle passes the winter only in the adult stage. The first severe frost in autumn forces the adults to go under grass, leaves, trash, etc., for protection. The exact date the beetles go into hibernation will vary somewhat, according to the two great controlling factors, temperature and food supply. However, they begin to collect under cover after the first killing frost. Some remain in the field as long as there is any green food. They have been found in the field as late as November 7th.

In the past two years we have taken screenings from late fall to early spring (Fig. 21). These were taken from places of every character that were thought to be suitable for insects to hibernate. These places were selected around the edges of tobacco fields and near old plant beds, both on high, well-drained land and on low land. The largest numbers of beetles were always taken along edges of woods adjoining the tobacco fields. Very few were taken more than twenty-five yards from the edge of the fields. These screenings were then placed in a covered battery jar and the jar placed in the warm sunshine. The beetles readily crawled up the sides of the jar where they could be secured very easily. The largest number taken in screenings was about 200 beetles per peck of leaves. These were secured early in the fall just after the first killing frost.

## TIME OF EMERGENCE

The tobacco flea-beetles are more or less active all the winter. The time of emergence in the spring seems to be largely determined by the food supply. Just as soon as any host plant appears near their hibernating places, these beetles attack it.

The earliest food plants to appear in the spring are the tobacco plants in the seed bed. These are attacked by the time the largest leaves are about the size of a dime. At first only a few beetles are to be found on the bed, but their numbers gradually increase as the season advances. Most of these appear within a period of three or four weeks.

FIG. 21—Screening for the Tobacco Flea Beetle to determine its prevalence in winter. (Original.)

## CONTROL MEASURES

The following control measures are recommended on a thorough study of the life history of the tobacco flea-beetle, and are believed to represent the best methods of attacking this pest. Special emphasis is laid upon three methods of attack: (1)The control of the insect on the plant in the bed, (2) the control of the insect at transplanting time, and (3) the destruction of the suckers after the crop is harvested. Not much emphasis has been placed upon the spraying of the plants in the field, for this method will not be necessary if the other methods are followed.

## CONTROL OF THE TOBACCO FLEA-BEETLE ON THE PLANT BEDS

The control of the tobacco flea-beetle on the plant beds is thought to be the one most important thing that tobacco growers can do towards controlling the pest. As stated before (page 28) practically all of the hibernating beetles attack the plants on the plant beds. Therefore a control of this insect here accomplishes two important results: (1) It insures a crop of good strong plants, and (2) it destroys the beetles so that they cannot attack the plant later in the field.

The following recommendations for the treatment of the plant beds are based on a consideration of the importance of controlling the tobacco flea-beetle on these beds:

## PLANT-BED TREATMENT

1. Locate the beds as far as possible from good hibernating quarters. If the plant-bed land is limited, and desirable locations are not to be had, be certain to burn a large area around the beds. Do not have surroundings like Fig. 24 without cleaning up and burning all the trash. If the beetles were abundant the previous season in the vicinity, take a favorable time and burn over the land for one hundred yards or more all around the beds. It is better to go too far than not far enough. The time to do this burning is preferably in the early winter, never later than the last of February.

2. Provide a good board frame and a tight beetle proof cover (Fig. 22); use only the best grade canvas, or use cheese cloth. Bury the boards in the ground a little and fasten on the canvas securely with strips, or stick it with tanglefoot or roofing paint. If the cover is not beetle proof, which condition is hard to obtain against this little active beetle, it can be made at least rather difficult for many to enter. The number attacking the plants before they begin to grow will be greatly reduced.

3. Provide a trap bed, or beds, near by the main bed on which the beetles may collect, and dust or spray this area thoroughly every week.

4. If the above precautions are not observed, or if the beetles get on

Fig. 22—A tobacco bed with a tight cover and a frame made of planking. A bed constructed in this way will go a long way towards controlling the Tobacco Flea Beetle.

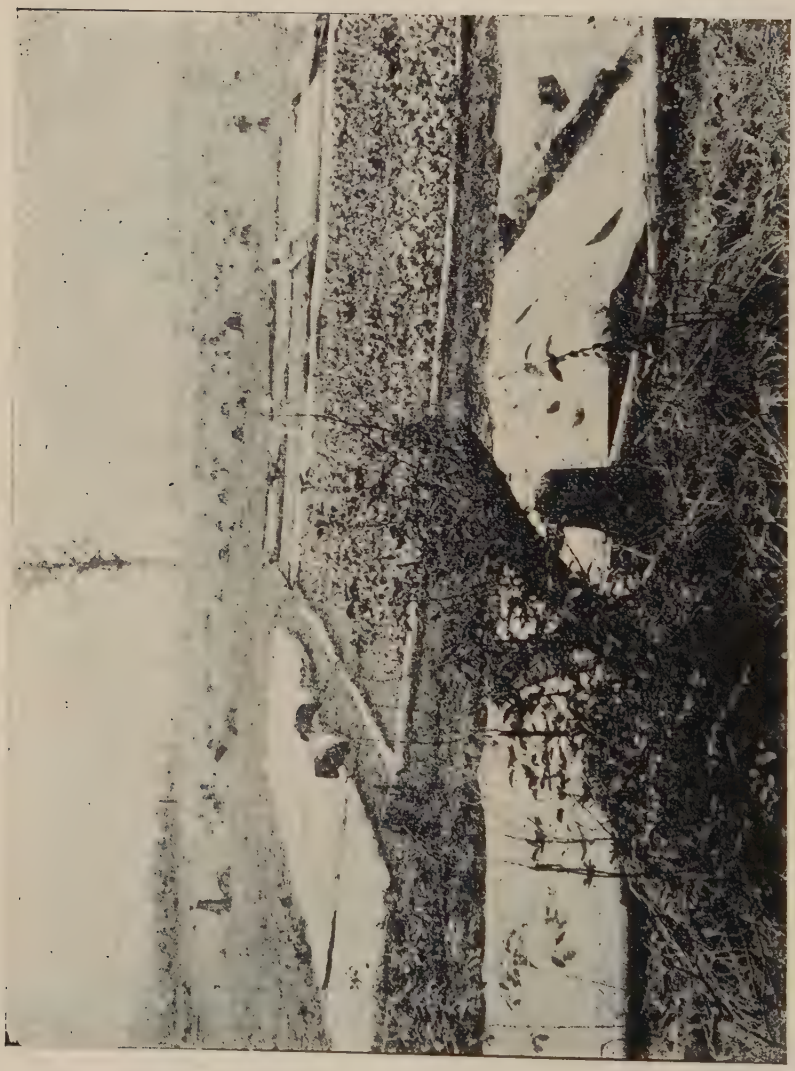

FIG. 23—Experimental beds. The large uncovered bed in the center was used as a check; the smaller beds surrounding the large bed were used to test various ways of dusting and spraying. (Original.)

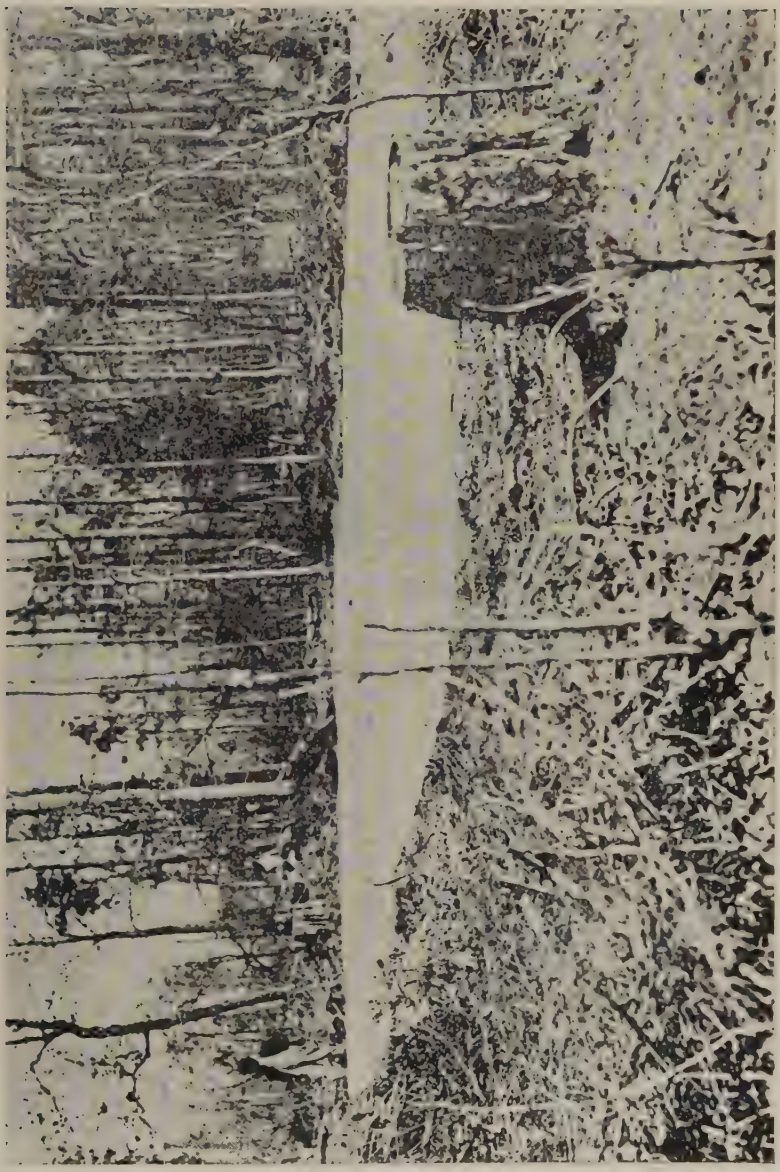

FIG. 24—The usual location for a tobacco plant bed, showing ideal hibernating places for Tobacco Flea Beetles. Such places should be cleaned up before the seed is sown. (See page 30.) (Original.)

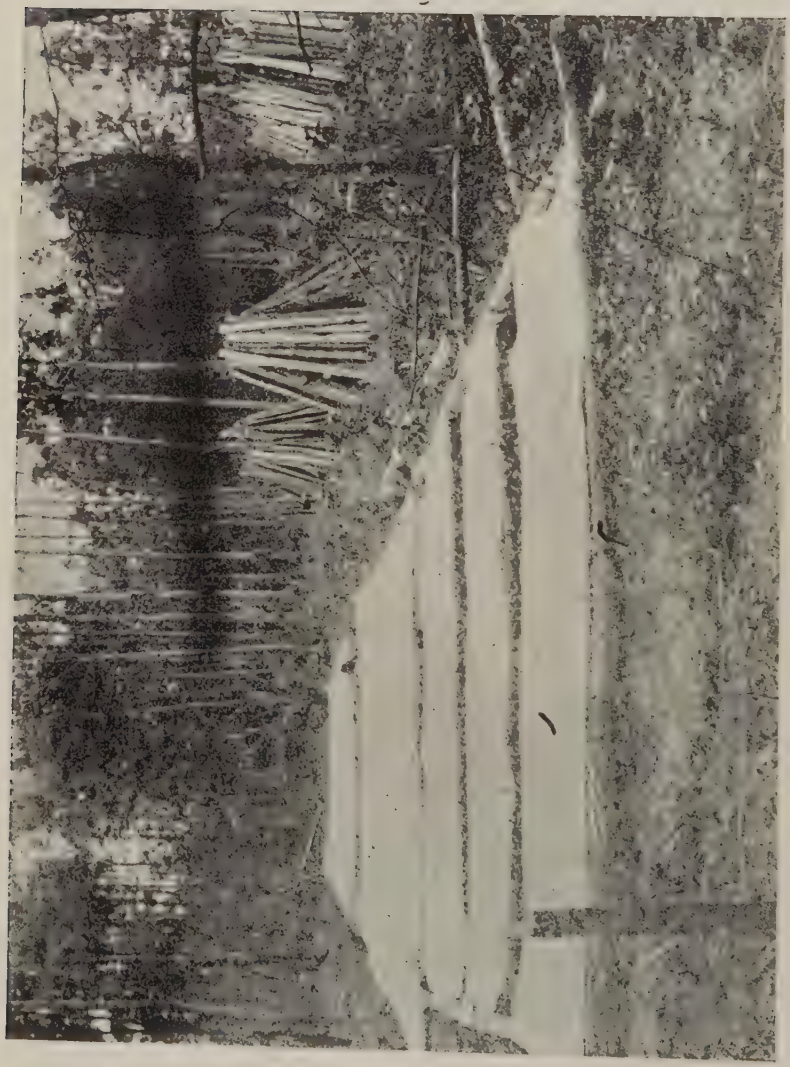

FIG. 25—The usual type of frame and cover. This cover offers no barrier to the Tobacco Flea Beetle. Contrast figure 22. (Original.)

FIG. 26.—Tobacco plants just coming up in the plant beds, showing the right time to make the first application of poison. The largest leaves are about the size of a dime. (Original.)

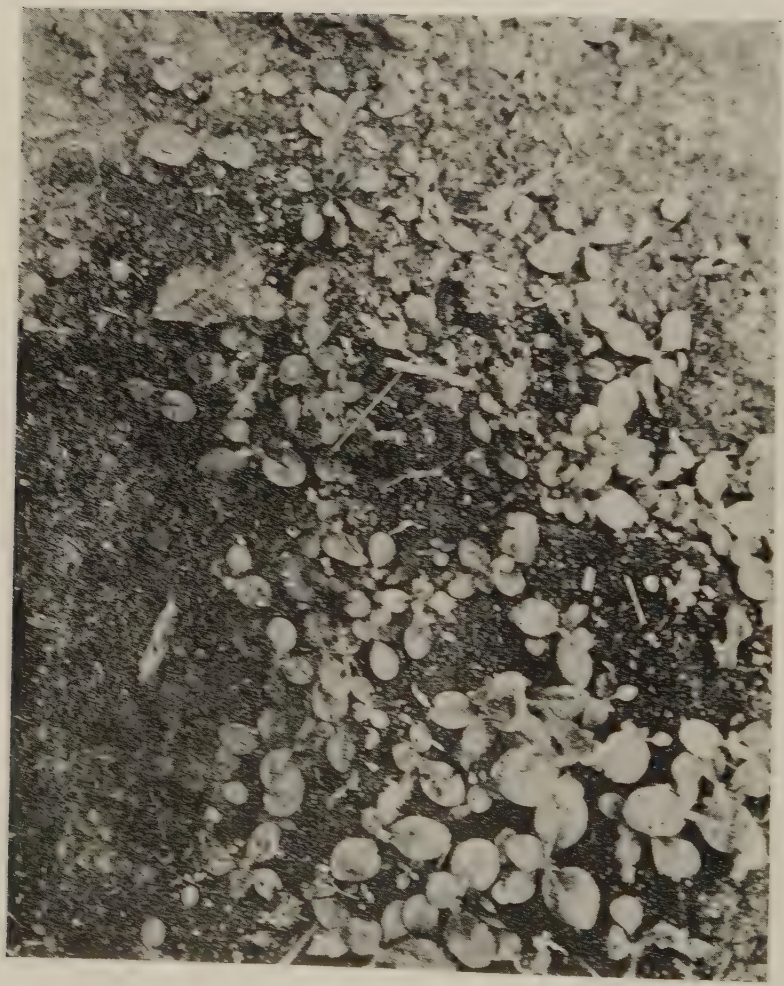

FIG. 27—Tobacco plants in plant beds. Too late to make the first application of poison. The largest leaves are about the size of a silver dollar. (Original.)

the main supply of plants under any conditions, spray or dust these thoroughly once every week until through setting out the crop. (See page 37.)

5. Be certain to treat the bed with a heavy application of poison immediately after transplanting the last of the crop, plow up the old bed, destroying every tobacco plant left, and plant some crop, or better, cover with straw or saw-dust to prevent weeds growing and to catch all weed seed. Rake this off when ready to sow seed for the next crop. Never leave the old bed for a breeding place, as is shown in Fig. 30, as the beetles continue to breed throughout the season; larvae and pupae were found as late as the first week in October in this bed.

## DUSTING AND SPRAYING THE PLANT BEDS

Since the results of the experiments show that nearly all of the tobacco flea-beetles gather on the tobacco beds in the early spring, an opportunity is presented to kill practically all of the overwintering beetles, thus greatly reducing the numbers to be found in the fields later on. It is doubtful if a better scheme could be devised for controlling this pest than the fact that they collect on the plant beds, as practically all of the beetles in the neighborhood are collected in a limited area which can be readily treated with an insecticide. With this in mind, a long series of experiments were carried on in dusting and spraying plant beds with arsenate of lead and arsenate of lime at different strengths. All of the mixtures checked the ravages of the tobacco flea-beetle, and in every case the plants on the treated beds were in much better condition at transplanting time than those on untreated beds close at hand.

As a result of these experiments it is recommended that the plant beds be sprayed with arsenate of lead (paste) at the rate of 1 pound to 10 gallons of water, or with arsenate of lead (powdered) or arsenate of lime at the rate of 1 pound to 20 gallons of water; or the plants may be dusted with powdered arsenate of lead or arsenate of lime mixed with fine sifted wood ashes at the rate of 1 pound of the poison to 4 pounds of the ashes.

Whether the farmer chooses to spray or dust his plants apparently makes no difference, as one method seems to be as effective as the other. The choice of methods will therefore depend upon the equipment available and the experience in spraying. It is much simpler and cheaper to dust the beds than to spray them. All that is required for dusting is that the poison be thoroughly mixed with the ashes at the rate mentioned above, and that the sack be made of cheese cloth or other thin material through which the mixture will sift slowly. It is absolutely necessary to mix the ashes and the poison thoroughly until the whole mass is light gray in color without any streaks or spots. This can readily be accomplished by placing the ashes and poison on a paper and mixing with a spoon or knife. The mixture should be dusted lightly and uniformly over the

whole bed, care being taken not to get too much of the mixture in one place.

The most convenient apparatus for spraying is what is known as a bucket pump with a lead of hose about 15 to 20 feet long and an extension rod about 3 or 4 feet long, provided with a disc nozzle.

The number of times it will be necessary to dust or spray the beds will depend upon a number of factors, the principal ones being the amount

FIG. 28—Very young tobacco plants badly damaged by Tobacco Flea Beetle.. (Original.)

of rain, as rain washes the poison from the leaves; and the rapid growth of the plants which offers fresh surfaces for the attacks of the beetles. The first application should be made just as soon as the plants are up (Fig. 26). The beds should then be watched closely, and as soon as small holes are noticed in the leaves, the beds should be treated again. This practice should be followed as long as the plants are in the beds.

## DIPPING THE PLANTS AT TRANSPLANTING TIME

At transplanting time the farmer should provide a tub or other large vessel filled with arsenate of lead solution prepared by mixing arsenate of lead (1 pound paste or ½ pound powder) in 5 gallons of water. This mixture should be carefully prepared and kept thoroughly agitated by stirring frequently with a paddle. Then as the plants are pulled from the bed they should be laid out straight in small bundles. Each bundle should be picked up separately and the leaves only dipped into the arsenate of lead solution. The plants should be separated as much as

possible while they are in the solution, so that every leaf will receive a coating of the poison. As the plants are withdrawn they should be shaken slightly to remove the excess poison. Care must be taken not to shake them too violently or too much of the poison will be removed.

FIG. 29—Young tobacco plants badly damaged by Tobacco Flea Beetle. (After Metcalf, N. C. Dept. Agr.)

After a few bundles are dipped look at the first bundles and notice whether the leaves are completely and uniformly covered with a dry white powder. If large drops of water have collected here and there on the leaf it means that the plants should be shaken a little bit more as they are removed from the poison. The plants can be set almost as rapidly in this way as by the old method. And the additional protection from flea bugs is very valuable indeed, as they are usually very destructive at transplanting time, due to the fact that they have been forced to

FIG. 30—A plant bed where the weeds have been allowed to grow. This furnishes an excellent feeding and breeding place for Tobacco Flea Beetles, and permits them to spread to the fields which are usually near-by. (Original.)

leave the plant beds, and also to the fact that the plants receive a very severe check at this season of the year. This will also aid in checking the beetles that come from outside sources. This method, if properly used, will not injure the plants in any way, but will stimulate the growth at this critical period.

## FIELD AND CULTURAL METHODS OF CONTROL

1. If beetles were present the previous season in the same field or near by, burn over the surrounding hibernating ground for a good safe distance. Do this before the seed is sown.

2. Break the land as early as possible; do not let volunteer plants come up from sucker seed, as they are likely to do around stumps and along the edges of the field.

3. Destroy every host plant (weeds, etc.) of the Solanaceous family (Fig. 5) in and around the fields. Do this persistently from early till late every season, until these are exterminated.

4. Set out a part of the crop, an acre or so, as early as possible, say ten or twelve days earlier than the main crop, at the most advantageous places for the beetles to collect as they come from hibernation. Dip these plants before transplanting (page 38) and spray or dust them thoroughly about twice before the main crop is put out. This will destroy the greater percentage of those that come from hibernation, and these are the most important ones to destroy, because they are the parents of all later generations.

5. Try to get out all of the main crops within two weeks. Late transplanted tobacco is usually thin and light, and the beetles will do great damage to all of the leaves from bottom to top.

6. Select seed from early maturing stalks only. Develop an early maturing variety. In selecting seed, in fertilization, and cultivation, carefully look out for earliness and uniformity in ripening. Late tobacco is nearly always badly damaged.

7. Have your tobacco seed thoroughly cleaned. The State Department of Agriculture, Raleigh, North Carolina, will clean a pound of tobacco seed for any farmer free of charge. For amounts of more than a pound a slight charge will be made. Cleaned seed means more uniform and better plants in the tobacco bed, hence better plants at transplanting time, thus insuring much more uniform plants in the field.

8. Practice frequent and thorough cultivation. This destroys large numbers of eggs, larvae, and pupae, all of which occur in the ground, at or near the surface. Keep a dry mulch around the base of the plants at all times. This gives less favorable conditions for the incubation of the eggs, and for the development of the larvae and the pupae.

9. Prime off the bottom leaves that lie on the ground. This should be done before the last cultivations. Nearly all larvae and pupae taken in the field were found under leaves which were on or near the ground.

FIG. 31—Suckers growing up in the field. These suckers should have been destroyed after the tobacco was harvested. (See page 44.) (Original.)

Fig. 32.—A near view of tobacco suckers, showing how they have been riddled by Tobacco Flea Beetles. (Original.)

These leaves offered shade and retained moisture in the soil which were favorable for the deposition and hatching of eggs, and the development of larvae and pupae.

10. Do not interplant any crop like cowpeas for instance, between the tobacco hills, or broadcast peas in the field, as this makes the best condition for the feeding of the beetles after the tobacco crop is harvested. In addition these plants shade the ground offering the best conditions for the development of the last generations of beetles, thus insuring that there will be a large number of beetles going into hibernation.

11. Remove all stumps, bushes and hedgerows in and around the tobacco field, as leaves blow against these and offer the best hibernating places.

12. It is important to work up community coöperation in all of these methods for the best results.

## DESTRUCTION OF ALL SUCKERS AFTER THE CROP IS HOUSED

The destruction of the suckers which grow up in the field after the tobacco crop is harvested is one of the cheapest and easiest methods of controlling the tobacco flea-beetle, as well as all other kinds of tobacco insects. If the tobacco grower will visit his field early in the fall and examine the suckers he would be impressed with the large numbers of tobacco flea-beetles, horn worms, bud worms, and all kinds of tobacco insects to be found in the field at this time. In other words the suckers simply afford an abundance of food for these destructive pests, from the time the crop is harvested until the pests are driven into winter quarters by killing frosts. If the tobacco farmer were to try and devise some method to insure an abundant supply of destructive pests for his next year's crop, it is doubtful if he could devise any better scheme than allowing the suckers to grow up in the field. The principal objection that is raised against this method is that the farmer is too busy to do this work at this season of the year. The authors of the bulletin appreciate the validity of this argument, as it is doubtful if there is a busier season on a tobacco farm than this season of harvesting, curing and marketing of the crop. To repay for the extra labor involved, the following advantages are urged: (1) That this will decrease the number of insect pests in the tobacco fields the following season to such an extent that the crop will be raised easier and cheaper enough to more than repay for the extra labor involved; (2) and that the suckers should be cut just at this season of the year, in order to enable the tobacco farmer to plant some cover crop. The advantages of planting a cover crop are so many and are generally so well understood that we need not discuss them further here.

The earlier these stalks are cut the better, as all of our experiments

FIG. 33—Leaves from suckers in the field completely riddled by Tobacco Flea Beetles. (Original.)

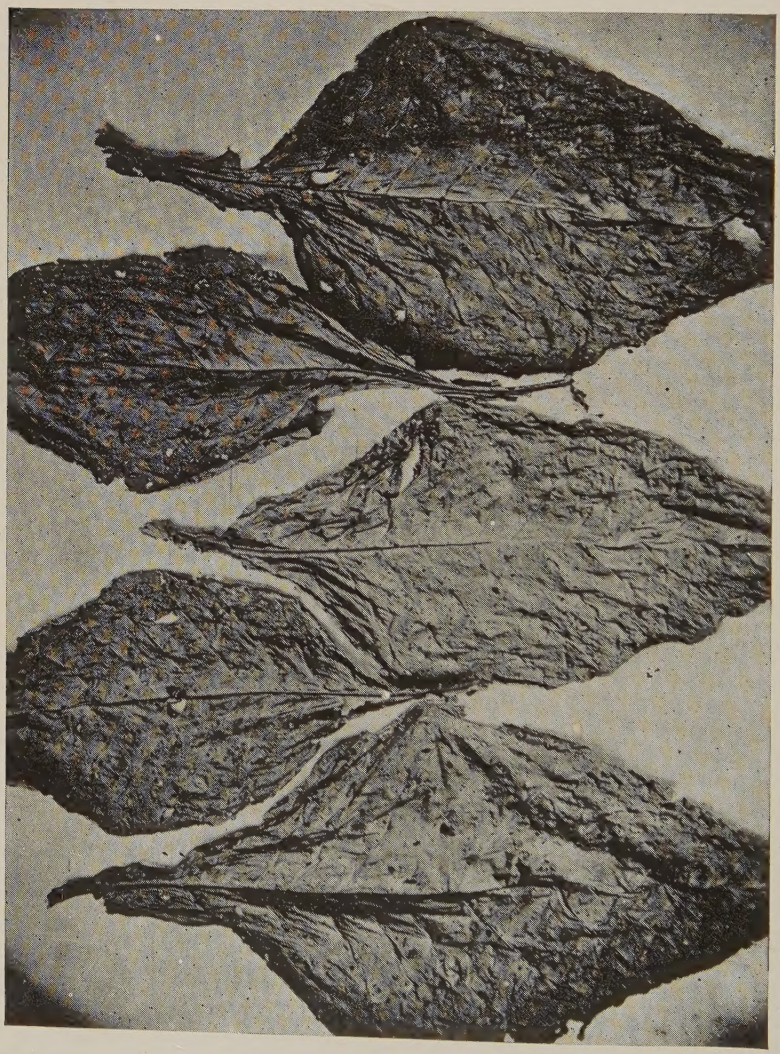

FIG. 34—Cured tobacco, showing the characteristic Tobacco Flea Beetle injury. Follow the proper methods of control and avoid putting such tobacco on the market. (Original.)

show that the earlier the adults are forced into hibernation the greater is the percentage that die before spring.

The stalks can be cut by hand with a sharp hoe, cutting the main stalk just below the surface of the ground so that sprouts will not come out, or they may be cut with a stalk cutter. Very effective work may be done with a disc harrow if a little care is taken. This has the additional advantage that it puts the ground in excellent condition for a cover crop.

This is another of the many places in which community coöperation will be found to be advantageous. Obviously the results will be very much better if this method of control is practiced by the whole community than if it is only practiced by isolated farmers.

## DUSTING AND SPRAYING THE TOBACCO IN THE FIELDS

Extensive experiments have been carried on relative to the advantage of dusting and spraying the plants in the field. The conclusion has been that where the other control measures as outlined above have been carried out faithfully, there will be no need to dust or spray the plants in the field. This is increasingly true if these measures are carried out as a community effort. Otherwise, the individual farmer is apt to find that his work has been set to naught because of the neglect of his neighbors. However, if any of the control measures are neglected it would be advisable to spray or dust the plants, especially when they are young. For this purpose use arsenate of lead or arsenate of lime, made up as directed for dusting and spraying the beds (page 37), but add one-half more water or carrier. However, the other methods are so much cheaper and so much more effective that if they are followed, for a series of years by a community, the tobacco flea-beetle will cease to be a pest.